QUANTUM MECHANICAL CALCULATION OF THE HADRONIC ATOMS AND SUPERHEAVY IONS: SHIFTS AND WIDTHS, HYPERFINE STRUCTURE FOR DIFFERENT NUCLEAR MODELS

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A great interest to the problem, in particular, stimulated by inaugurating the heavy-ion synchrotron storage cooler ring combination SIS/ESR at GSI. Witl this facility, which allows to produce, store and cool fully stripped heavy ions beams up to U^{92+} [1], new ways are opened in the field of nuclear spectroscopy and nucleus structure studying. Paper is devoted to calculation of the spectra, radiative corrections, fine, hyper fine structure parameters for superheavy ions and hadronic atoms with using different nuclear models. One of the main purposes is establishment a quantitative link between quality of the nucleus structure modelling and accuracy of calculating energy and properties of studied systems. We apply our nuclear code to calculation of spectra of the hadronic (pion, kaon, hyperon) atoms. Highly exact approach [2] to relativistic calculation of the spectra for multi-particle systems with an account of relativistic, correlation, nuclear, radiative effects on the basis of gauge-invariant quantum mechanical perturbation theory is used. Zeroth approximation is generated by the effective ab initio model functional, constructed on the basis of the comprehensive gauge invariance procedure [2]). The wave functions zeroth basis is found from the Klein-Gordon (pion atom) or Dirac (kaon, hyperon) equation. The potential includes the core ab initio potential, the electric and polarization potentials of a nucleus (the Fermi model, the gaussian form of charge distribution in the nucleus and the uniformly charged sphere are considered) [1,3]. For low orbits there are important effects due to the strong hadron-nuclear interaction (pion atom). The energy shift is connected with length of the hadron-nuclear scattering. In a case of superheavy ions the correlation corrections of the high orders are taken into account within the Green functions method. There have taken into account all correlation corrections of the second order and dominated classes of the higher orders diagrams (electrons screening, particle-hole interaction, mass operator iterations). The magnetic inter-electron interaction is accounted in the lowest (on α^2 parameter), the Lamb shift polarization part- in the Uhling-Serber approximation, self-energy part of the Lamb shift is accounted effectively with the use of the Green functions method. We carried out calculation: i).1s(2)2lj,3lj,4lj energy levels, hyperfine structure intervals for superheavy Li-like ions with account of the correlation, nuclear, radiative effects for different models of the charge distribution in the nucleus; ii). energy spectrum of the super heavy atom Z=114; iii). Shifts and widths of transitions (2p-1s,3d-2p, 4f-3d) in some pion atoms (^{18}O, ^{24}Mg etc.) and also K^--^4He.

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